KANSAS SOYBEAN COMMISSION FINAL REPORT OF PROGRESS

Title: “Breeding soybean to improve climate and disease resilience and compositional quality”

Accomplishments for FY2025 (July 1, 2024 – June 30, 2025)

Population and Germplasm Development

In 2025, about 100 new populations were created using more than 39 different parents. Over 60% of the single cross populations involved at least one parent resistant to soybean cyst nematode, several included drought and herbicide tolerance, and others incorporated novel traits such as reduced flower abortion or improved oil quality. Most of this work generates valuable germplasm and genetic tools that both public and private breeders can use to deliver new varieties. This ensures Kansas-developed germplasm remains in the commercial pipeline and ultimately reaches farmers.

Field Trials

The breeding program is currently evaluating more than 8,000 soybean genotypes planted in over 14,000 plots across Kansas. These evaluations include over 7,000 F4:5 progeny rows, providing the critical first look at early-generation material with potential to advance. Among these progeny, more than 2,000 lines were derived from high oleic parents to improve oil quality traits, while another 2,000 originated from slow-wilting or drought-tolerant parents aimed at improving resilience under water-limited conditions. In addition, more than 800 K-lines from maturity groups III through V are being tested in preliminary yield trials to identify promising candidates for advancement. Over 100 K-lines have progressed to the Kansas Advanced Yield Trials, which provide rigorous, multi-location testing under farmer-representative conditions. Beyond our program, over 230 breeding lines contributed by public programs nationwide, including 33 K-lines, are being tested in Uniform and cooperative trials across the U.S., providing an important measure of how Kansas germplasm performs relative to other breeding efforts. Finally, more than 400 experimental genotypes and plant introductions are under evaluation in specialized drought, remote sensing, and diversity yield trials, which are designed to expand genetic diversity and accelerate the identification of traits that will contribute to long-term yield stability and adaptability.

Variety Release

KS4525NS was officially released in FY25 as the latest public variety developed through the Kansas State University breeding program. The release notice is provided below, followed by tables summarizing its multi-year performance across Kansas environments. While production of public varieties like KS4525NS is typically on a smaller commercial scale, the release plays an important role in advancing soybean improvement by making new genetics available to both farmers and breeders. The variety was licensed for commercial production, providing growers with an additional option for local adaptation, and it has also been exchanged with other breeding programs through material transfer agreements.

Kansas Agricultural Experiment Station
Kansas State University
Manhattan, KS 66506

Notice of Release of KS4525NS Conventional (non-GMO) Soybean

The Kansas Agricultural Experiment Station announces the release of 'KS4525NS' soybean [*Glycine max* (L.) Merr.]. Scientists contributing to this release are William Schapaugh, Professor; Rene Hessel, Assistant Scientist; Garrett Glanzer, Assistant Scientist; and Addie Clary, Assistant Scientist; Department of Agronomy; and Tim Todd, Instructor; and Tom Oakley, Assistant Scientist, Department of Plant Pathology.

KS4525NS is an F_4 single plant selection from the cross LD07-3395bf x K11-2363T. KS4525NS has white flowers, gray pubescence, tan pods at maturity, an indeterminate growth habit, and seeds with buff hila. KS4525NS is a mid-group 4 variety (4.5). It is well adapted to a wide range of soil types and climates throughout Kansas and other areas where maturity group IV varieties are grown.

KS4525NS was tested as experimental line K18-1994 in Kansas and regionally beginning in 2019. KS4525NS performed well in the Uniform Soybean Tests: Northern Region from 2021 to 2024, including the Preliminary and Uniform Maturity Group IV Tests. The average yield of KS4525NS was higher than that of the check LD00-2817 and equal to the checks LD15-3818 and LD07-3395bf. The average maturity of KS4525NS was up to six days later than that of the checks. The plant height of KS4525NS is short, similar to that of check LD07-3395bf. The seed characteristics of KS4525NS generally fall within the range observed among the checks. Because of its performance, KS4525NS has been designated a mid-group IV check for the Preliminary and Uniform Soybean Tests in the Northern Region. KS4525NS is moderately resistant to HG Type 7 of soybean cyst nematode, with female indices ranging from 14 to 22% in the Uniform Test evaluations conducted from 2021 through 2023. KS4525NS is not resistant to glyphosate but possesses tolerance to specific STS® herbicides.

The Foundation Seed Program, Department of Agronomy, Kansas State University will maintain breeder's seed of this cultivar. Information on licensing for commercialization can be obtained from Christopher D. Brandt, President/CEO, Kansas State University Research Foundation, 2005 Research Park Circle, Suite 105, Manhattan, KS 66502-5020 (phone: 785-532-5720; email: tech.transfer@k-state.edu).

Small quantities of seed for research purposes can be obtained by request from William Schapaugh, Department of Agronomy, Kansas State University, Manhattan, KS (phone: 785-770-7906; email: wts@ksu.edu).

J. Ernest Minton

April 25, 2025

Date

Director, Kansas Agricultural Experiment Station

Table 1. Uniform Soybean Tests, Northern Region, Preliminary and Uniform 4, 4-Year Summary (2021-2024)

					Seed			
	Yield	Maturity	Lodging	Height	weight	quality	protein	oil
Entry	bu/a	date	score	in.	g/100	score	@13%	@13%
Locations	40	39	38	36	33	33	33	33
LD15-3818	**66.3a**	9/30b	1.4a	33b	15.5bc	1.7a	34.4a	19.9b
LD00-2817	**61.7b**	2c	1.8b	37a	13.7a	2.0a	32.7b	20.3b
LD07-3395bf	**65.5a**	-1a	1.5ab	30c	15.9c	1.9a	32.4b	20.7a
K18-1994	**66.4a**	5d	1.5ab	30c	14.9b	1.8a	32.9b	20.1b
Grand Mean, all entries	**62.3**	1.6	1.5	33.2	15.0	1.6	33.7	19.9

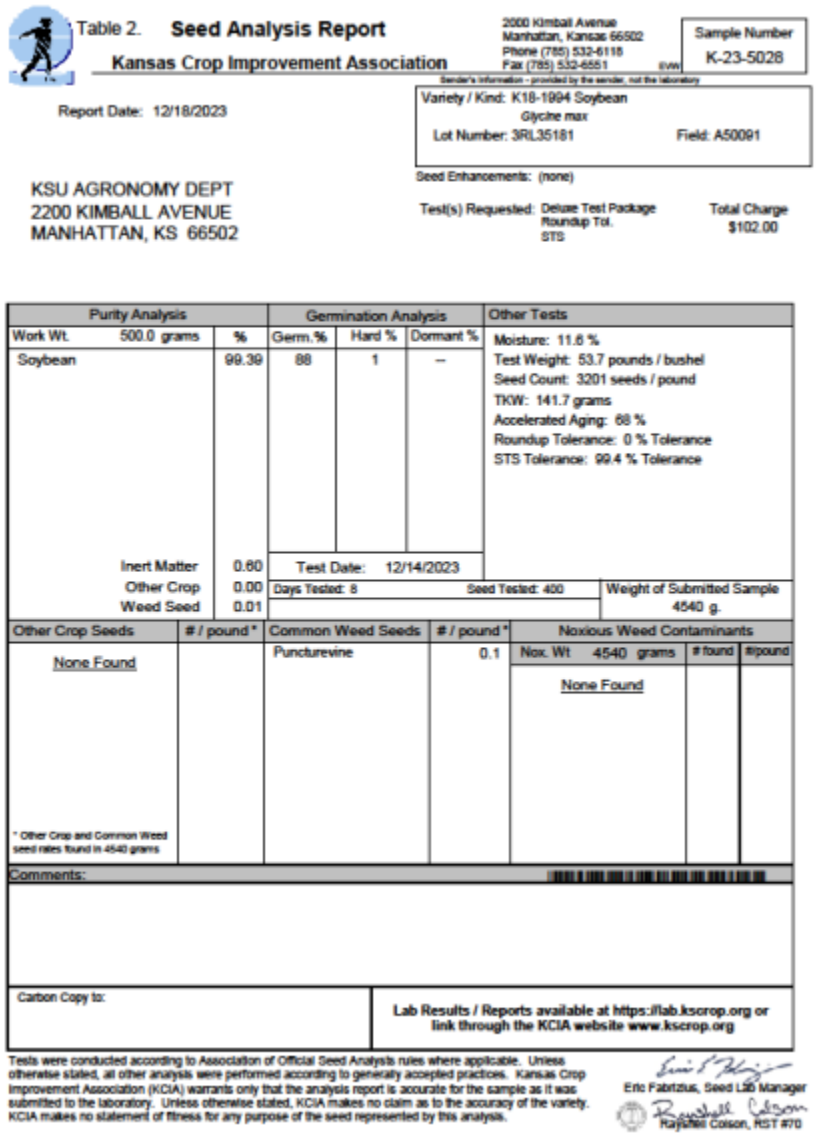


Table 2. **Seed Analysis Report**

Kansas Crop Improvement Association

2000 Kimball Avenue
Manhattan, Kansas 66502
Phone (785) 532-6116
Fax (785) 532-6551

Sample Number K-23-5028

Sender's Information - provided by the sender, not the laboratory

Report Date: 12/18/2023

Variety / Kind: K18-1994 Soybean
Glycine max
Lot Number: 3RL35181 Field: A50091

Seed Enhancements: (none)

KSU AGRONOMY DEPT
2200 KIMBALL AVENUE
MANHATTAN, KS 66502

Test(s) Requested: Deluxe Test Package, Roundup Tol., STS

Total Charge $102.00

Purity Analysis			Germination Analysis			Other Tests
Work Wt. 500.0 grams		%	Germ.%	Hard %	Dormant %	Moisture: 11.6 %
Soybean		99.39	88	1	--	Test Weight: 53.7 pounds / bushel
						Seed Count: 3201 seeds / pound
						TKW: 141.7 grams
						Accelerated Aging: 68 %
						Roundup Tolerance: 0 % Tolerance
						STS Tolerance: 99.4 % Tolerance
	Inert Matter	0.60	Test Date: 12/14/2023			
	Other Crop	0.00	Days Tested: 8		Seed Tested: 400	Weight of Submitted Sample 4540 g.
	Weed Seed	0.01				

Other Crop Seeds	# / pound *	Common Weed Seeds	# / pound *	Noxious Weed Contaminants		
				Nox. Wt 4540 grams	# found	#/pound
None Found		Puncturevine	0.1	None Found		

* Other Crop and Common Weed seed rates found in 4540 grams

Comments:

Carbon Copy to:

Lab Results / Reports available at https://lab.kscrop.org or link through the KCIA website www.kscrop.org

Tests were conducted according to Association of Official Seed Analysts rules where applicable. Unless otherwise stated, all other analysis were performed according to generally accepted practices. Kansas Crop Improvement Association (KCIA) warrants only that the analysis report is accurate for the sample as it was submitted to the laboratory. Unless otherwise stated, KCIA makes no claim as to the accuracy of the variety. KCIA makes no statement of fitness for any purpose of the seed represented by this analysis.

Eric Fabritzius, Seed Lab Manager

Rayshell Colson, RST #70

Germplasm Releases

After years of cooperative research, a valuable set of non-nodulating soybean lines has been developed through the joint efforts of the Department of Agronomy, Kansas State University, the Institute of Plant Breeding, Genetics and Genomics and Department of Crop and Soil Sci., University of Georgia, the Crop Genetics Research Unit, USDA-ARS, Stoneville, Mississippi, and the Department of Crop, Soil and Environmental Sciences, University of Arkansas, Fayetteville, Arkansas. The release announcement for this germplasm is below. This germplasm represents a unique and powerful resource for advancing our understanding of biological nitrogen fixation and nitrogen management in relation to soybean yield and seed composition. The lines have been deposited in the National Plant Germplasm System and are already being distributed to U.S. researchers, ensuring broad access to material that can drive both fundamental discoveries and practical advances in soybean improvement. A research article describing this work and germplasm has been accepted for publication in the Journal of Plant Registrations.

Kansas Agricultural Experiment Station (AES) and the Arkansas AES

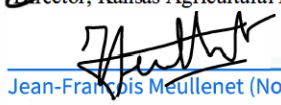
Notice of Release of Non-nodulating and Nodulating Isolines from Soybean Cultivar "KS4120NSGT'

The Kansas Agricultural Experiment Station (AES) and the University of Arkansas AES announce the release of four non-nodulating near-isogenic soybean [*Glycine max* (L.) Merr.] lines (KS4120-1_rj1, KS4120-2_rj1, KS4120-3_rj1, and KS4120-4_rj1), developed from the Harosoy NN source, and four nodulating lines (KS4120-5_Rj5/rj6, KS4120-6_Rj5/rj6, KS4120-7-1_Rj5/rj6, and KS4120-7-2_Rj5/rj6) and four non-nodulating lines (KS4120-5_rj5/rj6, KS4120-6_rj5/rj6, KS4120-7-1_rj5/rj6 and KS4120-7-2_rj5/rj6) developed from heterogeneous BC_4F_2-derived families from the William-NN source. Scientists participating in this development were Ugochukwu N. Ikeogu[1], Rene Hessel[1], Zenglu Li[2], Jeffery D. Ray[3], William T. Schapaugh Jr.[1], and Larry C. Purcell[4]

The recurrent parent, KS4120NSGT, and all near-isogenic lines are early maturity group 4 genotypes with purple flowers, tawny pubescence, brown pods at maturity, indeterminate growth habit. Seeds have yellow cotyledons, yellow seed coats, and black hilum color. Line advancement and selection for non-nodulation/nodulation from the elite × non-nodulation donors were made using both phenotypic and marker-assisted selection. Field evaluations across five environments in 2021 and 2022 demonstrated the superior performance in yield potential, agronomic traits, and adaptability of the recurrent parent as well as the lines compared to check NN genotypes, Harosoy-NN and William-NN sources. The lines are important resources in soybean studies to elucidate biological nitrogen fixation and nitrogen management in relation to soybean yield and seed composition.

Seed for research purposes of the near-isolines and the recurrent parent will be deposited in the United States Department of Agriculture National Plant Germplasm System.

Director, Kansas Agricultural Experiment Station — Date 11/20/2024



Jean-François Meullenet (Nov 26, 2024 17:58 CST)

Director, Arkansas Agricultural Experiment Station — Date

Scientists Affiliations: [1] Dep. of Agronomy, Throckmorton Hall, Kansas State Univ., Manhattan, KS, 66506, USA, [2] Institute of Plant Breeding, Genetics and Genomics and Dep. of Crop and Soil Sci., University of Georgia, Athens, GA 30602, [3] USDA-ARS, Crop Genetics Research Unit, Stoneville, MS, 38776, [4] Department of Crop, Soil and Environmental Sciences, University of Arkansas, 1366 W. Altheimer Drive, Fayetteville, AR 72704, USA

Breeding Technologies

- **Genetic gain.** Over the past several years we have worked to integrate spectral reflectance data into a predictive tool for yield. Spectral images were evaluated as predictors of soybean yield across multiple environments and years using a combination of mixed model and machine learning approaches. High-throughput reflectance measurements were collected with drone-based sensors at repeated sampling dates within each location, providing time-series data for a suite of vegetation indices including NDVI, NDRE, and related canopy metrics. Mixed linear models were used to generate BLUPs for both agronomic and spectral traits, incorporating genotype, location, and genotype × location effects while testing different strategies for aggregating spectral data across dates versus modeling each date individually. To extend beyond traditional variance-component methods, machine learning algorithms were applied to the spectral BLUPs to develop predictive models for yield, enabling comparisons of accuracy and robustness across environments. This integrated approach demonstrated that while prediction accuracy varied depending on trait, index, and environment, spectral reflectance data—particularly when combined with Machine Learning Methods—can capture genetic variation relevant to yield potential and provide a promising framework for accelerating early-generation selection in soybean breeding.
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- **Biotech traits.** We have focused efforts on crossing two of our transgenic lines (hpRNAi-Y25 and hpRNAi-Prp17) for SCN resistance into Kansas adaptive lines that are both susceptible and moderately resistant to SCN Hg type 7 as well as crossing the two transgenes together. Currently we have F4 generations to test. We are also continuing our work on two events (hpRNAi-cytoP450 and hpRNAi-Lacc2) showing promise for Dectes stem borer tolerance. We were unable to acquire the proper field release permits for the summer of 2025 due to personnel changes within the USDA earlier this year. However, we have continued advancing these lines in the greenhouse and begun crossing these two lines into KS adaptive lines.
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Drought and Heat Tolerance

- **Abiotic stress.** Data analysis continued on an a field experiment conducted in 2020, 2021 and 2022 to evaluate the response of a diversity panel of over 300 genotypes to heat stress. Phenotypic data collected included: days to physiological maturity (R8), seed quality, seed yield (kg/ha), seed weight (100 seed weight in grams), lodging, plant height (cm), and seed composition (oil, protein linoleic, linolenic, palmitic, stearic, raffinose, and sucrose concentrations). Genome-Wide Association and Genomic Prediction studies were conducted to identify genomic regions responsible for the phenotypic traits with the goal of developing improved heat-tolerant germplasm. These analyses should be completed in 2024.

Training, Outreach and Knowledge Dissemination

This project continues to strengthen both the soybean breeding pipeline and the broader agricultural community by training new scientists, engaging farmers, and contributing to the scientific literature. Multiple undergraduate students worked and trained with the breeding program throughout the year, while graduate students focused on applying remote sensing and machine learning to breeding research, and post-doctoral associates advance genomic evaluation and studies of physiological stress response. These training opportunities not only provide valuable research experience but also ensure a strong pipeline of future professionals in soybean improvement.

At the same time, project results are actively shared with producers and the scientific community. Findings are delivered through extension publications, news releases, radio interviews, experiment station reports, field days, extension meetings, and tours. Online resources provide up-to-date information on new germplasm releases, pest resistance, and results from SCN surveys, giving farmers practical insights for variety selection and management. Research on high temperature stress, host plant resistance, and SCN resistance is also disseminated at scientific conferences and through peer-reviewed publications.

Publications from FY25 include journal articles in Theoretical and Applied Genetics, Agronomy Journal, in silico Plants, and Crop Science, along with multiple abstracts presented at national meetings of the American Society of Agronomy, Crop Science Society of America, Soil Science Society of America, and the American Society of Plant Biologists. Together, these publications demonstrate the scientific rigor of the project and ensure that Kansas-led soybean research informs breeding and production decisions both locally and nationally.

Journal articles

Menke, Ethan, Clinton J. Steketee, Qijian Song, William T. Schapaugh, Thomas E. Carter Jr., Benjamin Fallen, and Zenglu Li. 2024. Genetic mapping reveals the complex genetic architecture controlling slow canopy wilting in soybean PI 471938. Theoretical and Applied Genetics DOI : 10.1007/s00122-024-04609-w.

Jenny Koebernick, Anne M. Gillen, Robert Fett, Sejal Patel, Ben Fallen, Vince Pantalone, Grover Shannon, Zenglu Li, Andrew Scaboo, William Schapaugh, Rouf Mian, Quentin D. 2024. Soybean test weight in relation to genotype, environment, and genotype × environment interaction in the Southern United States. Agronomy J. https://doi.org/10.1002/agj2.21551.

Chiozza, M.V., Parmley, K., Schapaugh, W.T., Asebedo, A.R., Singh, A.K. 2024. Changes in the leaf area-seed yield relationship in soybean driven by genetic, management, and environments: implications for high-throughput phenotyping. in silico Plants, 6(2): 123-135.

Wartha, C. A., Campbell, B. W., Ramasubramanian, V., Nice, L., Brock, A., Cai, G., Eskandari, M. M., Graef, G., Hudson, M. E., Hyten, D., Mahan, A. L., Martin, N. F., McHale,

L., Miranda, C., Dominguez, E. M., Nelson, R., Rainey, K., Rajcan, I., Scaboo, A., … Lorenz, A. J. (2025). Genomic analysis and predictive modeling in the Northern Uniform Soybean Tests. Crop Science, 65, e70138. https://doi.org/10.1002/csc2.70138.

Abstracts

U.C. Jha, S. Saffi, D. Chatti, W.T. Schapaugh, R. Welti, and P.V.V. Prasad. 2024. Transcriptome and Lipidome Dynamics of Soybean Floral Buds Under Heat Stress. American Society of Plant Biologists (ASPB) Midwest Section Meeting, March 16-17, 2024, at Purdue University in West Lafayette, Indiana.

Lima, J. E., Bolouri, F., Awan, A. S., Pramanik, S., Sari-Sarraf, H., Caragea, D., Turner, C., Dhandapani, R., Schapaugh, W. T. Jr., Ahmad, N., Ichinose, Y., Saini, D. K., Bangari, M. P. S., Bardhan, K., Mehla, M. K., Ye, H., Nguyen, H. T., Patil, G., Shekoofa, A., Fischel, L., Cruz, A., Somayanda, I., & Jagadish, K. (2024) Soybean Phenotyping Under Irrigated and Drought Conditions: A Machine Learning Approach for Flower and Pod Counting [Abstract]. ASA, CSSA, SSSA International Annual Meeting, San Antonio, TX. https://scisoc.confex.com/scisoc/2024am/meetingapp.cgi/Paper/161863.

Chatti, D., Walta, D., Todd, T., Ikeogu, U., Rainey, K. M., McHale, L., & Schapaugh, W. T. Jr. (2024) Phenotypic Selection for Seed Yield Using Spectral Imagery in Soybean Progeny Rows [Abstract]. ASA, CSSA, SSSA International Annual Meeting, San Antonio, TX. https://scisoc.confex.com/scisoc/2024am/meetingapp.cgi/Paper/159654.

Chatti, D., Schapaugh, W. T. Jr., Bakshi, A., Caragea, D., & Prasad, P. V. V. (2024) High Throughput Phenotyping to Evaluate Post Flowering Heat Tolerance in Soybean Using Pollen Germination [Abstract]. ASA, CSSA, SSSA International Annual Meeting, San Antonio, TX. https://scisoc.confex.com/scisoc/2024am/meetingapp.cgi/Paper/159051.

Schapaugh, W. T. Jr., Ikeogu, U., Hessel, R., Li, Z., Ray, J. D., & Purcell, L. C. (2024) Non-Nodulating and Nodulating Isolines Developed from Two Donor Sources and an Elite Soybean Cultivar [Abstract]. ASA, CSSA, SSSA International Annual Meeting, San Antonio, TX. https://scisoc.confex.com/scisoc/2024am/meetingapp.cgi/Paper/158977.

Acknowledgments

We sincerely thank Kansas soybean farmers for your continued support of this project through the Kansas Soybean Commission. The faculty, graduate students, post-doctoral scientists, and staff involved in this work all recognize that your checkoff dollars make this research possible. Because of your investment, we can develop new soybean germplasm, test innovative tools, and generate information that directly addresses the challenges you face in the field.

Your support allows us to stay focused on problems that matter most to Kansas agriculture—managing pests like soybean cyst nematode, improving tolerance to drought and heat, and enhancing seed quality traits that add value in the marketplace. While some of our varieties are released on a smaller scale, the germplasm, knowledge, and training produced by this program strengthen both public and private breeding pipelines. That means the improvements we make here ultimately reach your farms through better genetics and more resilient varieties.

On behalf of the entire team, thank you for trusting us with this responsibility. We value the opportunity to work for you, and we are committed to ensuring that every dollar invested in this program returns benefits to Kansas soybean farmers, now and in the years ahead.